CONCRETE STRAIN POLE PROGRAM

PSTSGN07

Version 1.65

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DISCLAIMER

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Section 1

INTRODUCTION

The Florida Department of Transportation's Strain Pole Program calculates the forces in the supporting cable, the applied pole loads and computes the required pole size based on revised pole specifications. The program should not be used to select poles designed for the old criteria unless the capacity of these poles is verified in accordance with the AASHTO Specifications.

The program is currently available on IBM compatible microcomputers only. The program is written in Microsoft Fortran. The coding follows the conventions of Fortran 77 except for specialized graphics commands. The program requires an IBM compatible PC with 512 K bytes of RAM and a hard disk. A math coprocessor is not required, however, the program may require ten times as much time to execute without one.

The program requires a color monitor. The color display should conform to CGA, EGA or VGA standards. An EGA or VGA system is recommended since the graphics with a CGA system are significantly cruder. The program automatically adapts to the display system available on the PC it is installed on.

Section 2

FIXED ASSUMPTIONS

1) The supporting cables are assumed to be erected with the following initial tensions based on the required cable size and the total span length.

For 3/8 inch diameter utility strength cable:

Span in feet	Initial Wire Tension in pounds
0 to 100	50.0
101 to 125	75.0
126 to 150	85.0
151 to 175	100.0
176 to 200	115.0
201 to 225	125.0
226 to 250	140.0
251 to 275	150.0
276 to 300	175.0
over 300	200.0

For 7/16 inch diameter utility strength cable:

Span in feet	Initial Wire Tension in pounds
0 to 100	75.0
101 to 125	100.0
126 to 150	125.0
151 to 175	150.0
176 to 200	175.0
201 to 225	175.0
226 to 250	200.0
251 to 275	225.0
276 to 300	250.0
over 300	275.0

The calculations for deflections and stresses using these initial tensions consider the cables to be erected when their temperature corresponds to the average for the area. Cables should not be erected and stressed when the temperature is near the extremes for heat or cold. Cables may be installed by directly providing these tensions or by using the inital cable sag included in the program output.

2) The following weights are used by the program in computing loads:

Item	Weight (pounds)
Aluminum 12" signal section	12.3
Disconnect and hanger	16.4
2-way bracket	5.3
3-way bracket	8.1
4-way bracket	10.1
Backplates	2.0
3/8" diam. cable	0.273 per foot
7/16" diam. cable	0.399 per foot
Control cable & messenger wire	0.821 per foot

3) For signs the weight applied is equal to the area of the sign times the weight per square foot inputted. No additional weight is added by the program internally to account for hangers, etc. The weight per square foot must account for these loads.

4) The basic wind pressure is computed in accordance with the formula given in section 1.2.5 of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. The height coefficient used is 1.0. The areas and the drag coefficients used are as follows:

Item	Area (sq. ft.)	Drag Coefficient
signal section	1.36	1.2
signs	as inputted	1.2
2-way bracket	0.44	1.0
3-way bracket	0.44	1.0
4-way bracket	0.44	1.0
3 Section Backplate	5.28	1.2
4 Section Backplate	5.97	1.2
5 Section Backplate	6.3	1.2
3/8" diam. cable	0.031 per foot	1.1
7/16" diam. cable	0.036 per foot	1.1
control & messenger	0.104 per foot	1.1
Disconnect & Hanger	0.856	1.45

5) The wind loading on the poles is computed using the appropriate height coefficients and a drag coefficient of 1.5. This value is slightly greater than the specification value of 1.45. The higher value is used to account for wind along the diagonal.

6) A safety factor of 2.5 is used in determining the maximum allowable load in the cables. The 3/8-inch diameter cable has an allowable capacity of 4,600 pounds and the 7/16-inch diameter cable has an allowable capacity of 7,200 pounds. Both cables are assumed to be composed of Utility Strength wire manufactured in accordance with ASTM A 475 with 7 wires per cable.

7) Wind loads are applied to each cable in three directions; orthogonal to the cable, parallel to the cable and at an angle of 45 degrees to the cable span. When the wind is applied orthogonal to the cable an additional component of 0.2 times the wind force on the traffic signals and signs is applied to the cable along the cable span. A similar 0.2 component is applied orthogonally to the cable for wind loading applied along the cable.

8) Poles that have only one cable attached to them have the maximum horizontal cable force, for a given loading, applied to them to account for wind in either direction. The difference in the horizontal forces between the cable ends for orthogonal wind loading is due to the 0.2 component addressed in item 7.

9) Foundation depths are calculated using Broms method for cohesionless or cohesive soils with a safety factor of 1.5.

10) Pole lengths are rounded up to the nearest 2 foot increment and the additional length is added to the foundation depth.

11) The maximum deflection due to dead load only is used to determine the pole height required to maintain the specified clearance.

12) The deflection of the poles, due to loading, is not used when the cable forces are determined. Poles are assumed to have no horizontal deflection, this is a conservative assumption.

13) The possible deflection of the traffic signals and signs, due to wind loading, and the corresponding reduction in the forces applied to the cable, can be considered at the user's option. The restraint provided by the tether and messenger wires should be considered when setting this parameter.

14) The modulus of elasticity used for the cable is 24,500 ksi.

15) The moment capacity of the poles is assumed to vary linearly with the angle of the applied moment. Poles have around 71 percent of the 0 degree moment capacity to resist loads applied at 45 degrees to the strong axis.

16) The program assumes that the angles between cables in a box arrangement are 90 degrees. Intersections in which the cable angles at the corners are within 15 degrees, plus or minus, of 90 degrees (angles of 75 to 105 degrees) should produce acceptable results.

17) The program assumes that each support cable takes all of the applied dead and wind loads with out interacting with any other cable or structural element. Installations where other cables within the span take some of the load or restrain the support cable should not be designed with this program. In addition "suspended box configurations" are outside the scope of this program.

Section 3

METHODOLOGY

The basic method for analyzing the support cable is taken from the paper, by James Michalos and Charles Birnstiel, "Movements of a Cable Due to Changes in Loading", in the ASCE Journal of the Structural Division, December, 1960, pages 23 through 38. This paper addresses vertical loads only, but the basic vector techniques are applicable for loads in three dimensions. Instead of using the graphical method, of Michalos and Birnstiel, for determining the final forces, an iterative technique is used. The corrective values needed to make this method work are taken, with slight modifications, from a paper, by W. Terence O'Brien and Arthur J. Francis, "Cable Movements Under Two-Dimensional Loads", in the ASCE Journal of the Structural Division, June, 1964, pages 89 through 123.

The reduction in wind loading used for free swinging traffic signals and signs is from a paper by James F. Marchman, "Wind Loading on Free-Swinging Traffic Signals" in the ASCE Transportation Engineering Journal, May 1971. The paper does not provide explicit values but gives experimental results which allows the information to be derived.

The initial dead load configuration is calculated using the basic equation for a catenary. The cable is divided into 20 segments with the cable dead load applied at the nodes of these segments. Additional nodes are then created, with subsequent additional segments, at each location where a sign, traffic signal or additional load is applied. Up to 30 load locations are allowed per cable, for traffic signals and signs. Loads in the X,Y or Z coordinates may be applied at each node due to the combination of dead and wind loads.

The program, after the nodes are set, chooses the initial forces at the left end of the cable. Using this starting point the program then attains the deflections at each node and the forces in each segment. If the calculated location of the last node is within 0.001 inches of the actual end of the cable, the analysis of the cable is considered complete. If the calculated location of the last node is not within the 0.001-inch tolerance the forces at the left end of the cable are adjusted and the analysis starts over with the new forces. Load cases where the loading is predominately vertical and transverse to the cable span usually close after 5 or 6 iterations. Load cases where there is significant loading in the direction of the cable span typically take 12 or 13 iterations to close.

Section 4

INPUT DATA

Initial Data

1) TITLE
   Any name or phrase as suits the user up to 60 characters.

2) CROWN ELEVATION
   The highest elevation (ft.) of the roadway the support cable traverses.

3) WIND SPEED
   The wind speed for which the system should be designed based on a 25 year recurrence interval. This program requires the wind speed be either 70, 80, 90, 100 or 110 mph.

4) REQD CLEAR DISTANT
   The minimum distance in feet from the crown of the roadway to the bottom of the lowest signal or sign. A typical value is 18 feet.

5) TYPE
   A value of 1, 2, 3 or 4 is entered based on the configuration that will be analyzed. The screen shows the available arrangements in a schematic plan view.

6) TOP OF FDN.
   The final grade elevation at the location where ELEV. @ POLE the pole will be installed (ft.).

7) SPAN OF CABLE
   The horizontal span of the cable (ft.).

Unless otherwise directed; by the Department or an updated version of the Roadway Plans Preparation Manual, the design wind speeds by county are as follows:

70 MPH
Alachua, Baker, Bradford, Calhoun, Clay, Columbia, Gadsden, Gilchrist, Hamilton, Holmes, Lafayette, Lake, Leon, Liberty, Jackson, Jefferson, Madison, Marion, Putnam, Sumter, Suwannee, Taylor, Union, Wakulla, Washington

80 MPH
Bay, Charlotte, Citrus, Desoto, Dixie, Duval, Escambia, Flagler, Franklin, Glades, Gulf, Hardee, Hendry, Hernando, Highlands, Hillsborough, Lee, Levy, Manatee, Nassau, Okaloosa, Okeechobee, Orange, Osceola, Pasco, Pinellas, Polk, Santa Rosa, Sarasota, Seminole, St. Johns, Volusia, Walton

90 MPH
Brevard, Collier, Indian River, Martin, St. Lucie

100 MPH
Broward, Dade, Monroe, Palm Beach

Cable Data

Data unique to each cable is entered on a per cable basis. The cable is oriented as if the user is standing in the center of the intersection.

Can Signs and Signals Swing?

This question is to determine if the signs and traffic signals are attached so that they are free swinging. This would mean that under high winds they could swing up to a horizontal position to reduce the applied wind load. If it is indicated that they are free swinging the wind load applied in the direction orthogonal to the cable span is reduced to 65 percent of its original value. The wind loads along the cable span are not altered. If the user is unsure of the installation configuration, the conservative answer to this question is to assume the signs and signals are not free swinging.

Traffic Signal Data

The questions should be self explanatory. There are defaults for several of these items that will be displayed and inputted if the question is answered with a return.

Item	Default Value
Number of Sections	3
1,2,3 or 4 Way?	1
Backplates (Yes or No)	N

Backplates are considered to be the size required for the direction with the maximum number of sections. If the signal is indicated to be one way the program will not ask for the maximum number of sections in a direction. The question concerning the distance of the signal from the left pole is the distance in feet to the center of the signal. The traffic signals depicted in the upper portion of the screen are icons and will look the same regardless of the number of sections or directions. They will, however, be placed proportionally to their location on the actual span.

Sign Data

There is a default for the weight per square foot of the sign of 3 psf. A 1/8-inch thick sign panel has a weight of approximately 1.8 psf such that 3 psf should typically be sufficient to cover the weight of backing beams and attachments in addition to the sign panel. The distance from the left pole to the sign, as requested by the program, is to the center of the sign panel. For most monitors and video boards, the sign panels and the location should be proportionally displayed in the graphics window that appears above the text. All signs are assumed to be oriented parallel to the cable. This is a conservative assumption since this produces the greatest load on the cable from wind loading.

Additional Load Data

This feature is provided to account for the loads induced by banners, decorations, etc., that may be hung from the support cable. These loads are applied as inputted regardless of the wind load direction being analyzed except only the vertical loads are applied for the dead load case. One set of additional loads may not be appropriate to get rational loads for all wind cases. This feature may require that the user combine cable loads by hand to get reasonable pole forces.

Soil Data

The program asks if the soil is clay or sand (cohesive or cohesionless). If the soil is a sand, the program requests the soil friction angle and the unit weight. In lieu of more exact information, reasonable conservative values for these variables are a friction angle of 30 degress and a unit weight of 105 pounds per cubic foot, these are the default values. If the soil is a clay the program requests the cohesion. The default value for cohesion is 1000 psf.

Section 5

OUTPUT DATA

Input Data

After the initial data is replicated and the configuration type indicated, cable input data is reproduced with traffic signals, signs and additional loads listed separately as they are during input.

Cable Results

Results are presented for dead load and three combined dead load - wind load cases. The DL+90 WL case indicates dead load plus wind load applied orthogonally to the cable. The DL+45 WL case indicates dead load plus wind load applied at 45 degrees to the cable span. The DL+0 WL case indicates dead load plus wind load applied parallel to the cable span. For each load case, results for the horizontal, vertical and transverse values at the left end of the cable are presented first followed by the right end values.

Pole Reactions

The program internally combines the results for each cable to get the pole reactions for three different dead load - wind load cases. DL + Y WL indicates the pole reactions resulting from dead load plus wind applied in the y direction. The y direction corresponds to the vertical axis of the computer screen when the configurations are shown in the plan view. DL + 45 WL is for dead load and wind applied along the diagonal of the configuration. DL + X WL indicates pole reactions due to dead load plus wind applied along the x axis which corresponds to the horizontal axis of the screen. The load angle presented here indicates the direction of the maximum applied moments. These angles account for the orientation of the pole which is dependent on the configuration or type. Poles with two cables attached are aligned with the loaded face at 45 degrees to each cable. Poles with one cable attached are aligned so that the loaded pole face is orthogonal to the cable span. A zero degree angle indicates that the pole orientation is the optimum to resist the applied loads.

Soil Values

The program at this location merely duplicates the information inputted concerning the soil properties.

Pole Results

The pole number and base elevation displayed at this location are simply the values inputted earlier in the program. The total length indicated is the pole length required plus whatever additional amount is needed to obtain an even two-foot increment for the pole length. The necessary additional length is added to the foundation depth to maintain the correct pole protrusion above grade. The pole type is based on the required moment capacities indicated in the specifications. These pole types do not correspond directly with earlier poles fabricated in accordance with specifications prior to the Department's 1991 specifications. Earlier pole types cannot be substituted for poles built to current specifications.

Section 6

SAMPLE PROBLEM

```
***** ****   ***  *****
*     *   * *   *   *
***   *   * *   *   *
*     *   * *   *   *
*     ****   ***    *

 ***  ***** ****   **  * *   *
*       *   *   * *  * * **  *
 ***    *   ****  **** * * * *
    *   *   *  *  *  * * *  **
****    *   *   * *  * * *   *

****   ***  *    ****
*   * *   * *    *
**** *   * *    ***
*     *   * *    *
*      ***  **** ****

****  ****   ***   ***  ****   **  *     *
*   * *   * *   * *     *   * *  * **   **
****  ****  *   * *  ** ****  **** * * * *
*     *  *  *   * *   * *  *  *  * *  *  *
*     *   *  ***   ***  *   * *  * *     *
```

TIME 11: 8:29
DATE 4/21/1992

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FILENAME -->example.out

TITLE --> example

CONFIGURATION TYPE 4

```
1----------2
```

```
THE ELEV. OF THE CROWN (FT)  = 100.0000
THE DESIGN WIND SPEED (MPH)  =  90.0000
THE REQUIRED CLEAR DIST.(FT) =  18.0000
```

```
*****************
*LOADS PER CABLE*
*****************


***CABLE 1***      SPAN =    160.000   POLE 1 TO POLE 2
   TRAFFIC SIGNALS  (FREE SWINGING)
  #  SECTS.      #  DIRECT.    #  SECTS./DIRECT.    BACKPLATES
DIST. LF. POLE

 (FT)
   3.00          1.00             3.00                    N
  35.0000
   3.00          1.00             3.00                    N
  88.0000
   3.00          1.00             3.00                    N
 120.0000
         SIGNS  (FREE SWINGING)
  LENGTH      DEPTH     PANEL WT.    DIST. LF. POLE
   (FT)        (FT)       (PSF)          (FT)
   5.00        2.00        3.00          45.0000


     ***********************
     *CABLE RESULTS IN KIPS*
     ***********************



***CABLE 1***   MAX CABLE TENSION (K) =   3.567
                CABLE SIZE = 3/8 INCH DIA. UTIL
                MAXIMUM CABLE DEFL. =   111.46 INCHES
                INITIAL CABLE SAG = 107.90 INCHES
  CASE       L HORIZ   L VERT    L TRANS   R HORIZ   R VERT
 R TRANS
   DL          .8824     .1728     .0000     .8824     .1595
   .0000
DL+90 WL     3.4882     .1755     .7247    3.4882     .1568
   .5979
DL+45 WL     2.9082     .1852     .5399    2.9082     .1471
   .3953
DL+ 0 WL     1.3169     .2013     .0848    1.3169     .1309
   .0444

       ----HANGER LENGTHS----  (STARTING @ POLE 1)
     HANGER #     DIST. FROM POLE (FT)     LENGTH (INCHES)
         1               35.00                  43.18
         2               45.00                  30.78
```

3	88.00	12.00
4	120.00	39.12

<<< ERRATA >>>

****
POLE REACTIONS
****

POLE #	LOAD CASE	BASE MOM (IN-K)	BASE SHR (K)	LOAD ANGLE (DEGREES)
1	DL + Y WL	1654.474	4.576	28.341
1	DL + 45 WL	1655.559	4.967	20.022
1	DL + X WL	1033.224	2.475	1.964
2	DL + Y WL	1630.015	4.495	26.703
2	DL + 45 WL	1635.869	4.906	18.035
2	DL + X WL	1032.784	2.474	1.029

****
SOIL VALUES
****

SOIL FRICTION ANGLE (DEGREES) = 30.00
SOIL WEIGHT (PCF) = 105.00
COHESION (PSF) = .00

****
POLE RESULTS
****

POLE #	T.O.F. ELEV. (FT)	TOTAL LENGTH (FT)	FDN DEPTH (FT)	POLE TYPE
1	98.000	44	8.212	NVI
2	98.000	44	8.212	NVI